

FOOTWEAR PIECE WITH CUSHIONING SYSTEM AND
METHOD OF ABSORBING IMPACT FORCES ON
THE FEET OF A WALKER OR RUNNER

BACKGROUND OF THE INVENTION

5 FIELD OF THE INVENTION

This invention relates to footwear and, more particularly, to a cushioning system for absorbing impact forces generated against the feet of a wearer of the footwear as the wearer walks or runs. The invention is further directed to a method of absorbing impact forces on the feet of a walker or runner.

10 BACKGROUND ART

The footwear industry is constantly seeking out new footwear designs that reduce the deleterious effects of impact forces encountered as individuals wearing the footwear walk or run. As individuals walk or run, potentially damaging impact forces are imparted to the feet, knees, hip and back.

15 Each foot normally makes initial contact with an underlying surface at the heel region with the forward region raised and the toes pointed angularly upwardly. Continued downward movement brings the forward pad and toe region into contact with the underlying surface. Ultimately, the user generates thrust by pressing the pad and toe region against the underlying surface with
20 the heel region slightly raised. Repeated impact, through either walking or running, frequently causes injury. This injury may be limited to the foot, but is commonly inflicted on in the knees, hips, and even in the back region. Progressive degradation of cartilage, tendons and joints commonly occurs in the population from running, and even casual walking. These conditions may
25 be aggravated depending upon the weight, condition and body configuration for a particular individual.

Many decades ago, there was little appreciation for the need to absorb the above mentioned impact forces generated through walking and running. Footwear for both walking and running was commonly made with a substantially flat platform to bear the weight of the user. Impact absorption was effected through a relatively thin inner pad and compression of the sole and heel material. The compression characteristics were variable depending upon the composition of the platform.

Footwear design has drastically improved. Modern designers focus on providing conforming padding, primarily in the region which envelops the bottom portion of the foot, and "shock absorbing" structure in the heel region. Many different approaches have been taken to absorbing impact at the heel region. Different materials with different compressibility have been incorporated. Springs, flexible beams, fluid filled bladders, and voids have been strategically incorporated for this purpose. While certainly modern footwear design has improved drastically, often the above types of structures are incorporated more as marketing gimmicks than for their effectiveness due to travel and material absorption restrictions.

One problem inherent to a number of these designs is that they have a diminishing ability to absorb each impact. This problem can be explained with respect to an exemplary, liquid filled bladder commonly used in footwear. As a force is imparted to the bladder, a certain amount of "give" results from the reduction in the volume of any gas pocket(s) within the bladder under the weight of the user. As the force imparted to the bladder increases, any additional significant absorption of impact forces is accomplished primarily by stretching of the bladder material and reducing the volume of the liquid. The effect from the latter is minimal. The effect from the former is limited by the available volume for the liquid to expand into and the inherent stretchability of the bladder material. The bladder is initially conformable up to a point, and

thereafter assumes a relatively rigid form which accomplishes little in terms of force absorption.

5 The same effect results from the use of "springs" made of compressible materials, or otherwise, in the heel region. For example, a coil spring has a diminished ability to absorb impact forces as it is compressed. The same effect can be seen with different compressible materials used in the heel.

10 Another drawback with current footwear design is that it is made generically for a given foot size. Unfortunately heavy persons may have small feet and light persons may have large feet. This is not taken into consideration and thus a single design is offered for a particular shoe size. As a result, those individuals with specific footwear requirements may be forced to have their footwear customized. This is often an inconvenient and expensive proposition.

15 The footwear industry continues to seek out improved designs. The need for better designs becomes even more compelling given the larger number of active persons and the ongoing risk of injury that often proves debilitating. Footwear with an improved ability to absorb impact forces during walking or running potentially increases the effective life of an athlete's career and, allows those with an active lifestyle to comfortably enjoy activities for a longer period, and potentially avoids injuries that may lead to inactivity and
20 eventually medical problems that contribute universally to rising medical costs.

SUMMARY OF THE INVENTION

25 In one form, the invention is directed to a footwear piece having a platform and a fluid assembly. The platform supports a wearer's foot and is engagable with an underlying surface. The platform has a rear heel region for engaging the wearer's heel and a sole region forwardly of the heel region for engaging a portion of the wearer's foot including the ball and toes of the wearer's foot. The fluid assembly has a first chamber containing a first quantity of a first fluid. The fluid assembly is provided on the platform and configured

so that as the wearer of the footwear piece walks or runs, the wearer's heel is caused to apply a force to the first chamber that causes at least a portion of the first quantity of the first fluid to be discharged from the first chamber in such a manner that impact forces imparted from the platform to the wearer's heel are absorbed.

In one form, the fluid assembly has a second chamber into which the discharged fluid from the first chamber flows.

A restriction may be provided between the first and second chambers that controls flow of fluid from the first chamber into the second chamber.

In one form, the restriction is defined by a valve.

The valve may be of a fixed configuration or adjustable to vary a rate at which fluid flows from the first chamber into the second chamber for a given pressure in the first chamber.

In one form, the valve is constructed so that it restricts fluid flow from the first chamber into the second chamber to a greater extent than fluid flow from the second chamber into the first chamber.

In one form, the second chamber is provided on the platform and configured so that as a wearer of a footwear piece walks or runs, the ball of the wearer's foot is caused to apply a force to the second chamber to cause the fluid in the second chamber to be discharged into the first chamber.

In one form, the first liquid may be at least one of a liquid and a gas.

In one form, the first chamber is defined by a bladder made from at least one reconfigurable sheet layer.

In one form, the fluid flows in a first path in a first flow direction from the first chamber to the second chamber and oppositely to the first flow direction in the first flow path flowing from the second chamber to the first chamber.

In another form, the fluid flows in a first path from the first chamber to the second chamber and in a second path different from the first path from the second chamber to the first chamber.

In one form, the fluid assembly is repositionable relative to the platform to be installed in, and separable from, the platform as a unit.

In one form, the valve includes a live hinge portion.

The fluid assembly may be a closed system within which the first fluid
5 circulates.

The invention is further directed to a method of absorbing impact forces through a footwear piece on a wearer's foot. The method includes the steps of: providing a footwear piece having a) a platform for supporting a wearer's foot and engaging an underlying surface and having a rear heel region for
10 engaging the wearer's heel and a sole region forwardly of the heel region for engaging a portion of the wearer's foot including the ball and toes of the wearer's foot; and b) a first fluid assembly with a first chamber capable of containing a first quantity of a fluid; and causing fluid in the first chamber to be discharged from the first chamber as a wearer of the footwear piece walks or
15 runs and the wearer's heel applies a force to the first chamber such that impact forces imparted from the platform to the wearer's heel are absorbed.

In one form, the step of providing a footwear piece may involve providing a footwear piece with a second chamber and the step of causing fluid in the first chamber to be discharged involves causing fluid in the first chamber to be
20 discharged to the second chamber.

The method may further include the step of causing fluid in the second chamber to flow into the first chamber as a wearer of the footwear piece walks or runs and the ball of the wearer's foot is caused to apply a force on the second chamber.

The method may further include the step of providing a restriction to flow
25 between the first chamber and the second chamber.

In one form, the step of providing a restriction involves providing an adjustable valve through which a variable restriction to flow between the first chamber and the second chamber can be selected.

The method may further include the steps of providing a second fluid assembly similar to the first fluid assembly and with different operating capabilities, selecting one of the first and second fluid assemblies based on its ability to absorb impact forces based on at least one of foot size, weight, or body type of a wearer, and utilizing the selected one of the first and second fluid assemblies.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side elevation view of a foot during one stage of walking/running at which the heel is impacted with an underlying surface;

Fig. 2 is a view as in Fig. 1 in a stage at which the user has pivoted on the heel to place the ball of the foot and toes in contact with the underlying surface for a push-off;

Fig. 3 is an elevation view of a footwear piece in a position corresponding to the foot position in Fig. 1;

Fig. 4 is a view as in Fig. 3 with the footwear in a position corresponding to the foot position in Fig. 2;

Fig. 5 is a view as in Figs. 3 and 4 with the footwear piece shown with the foot elevated and in a striding position;

Fig. 6 is a partially schematic, plan view of one form of fluid assembly, according to the present invention, operatively positioned relative to a platform on a footwear piece for a wearer's right foot;

Fig. 7 is a partial cross-sectional, side elevation view of the fluid assembly and platform in Fig. 6;

Fig. 8 is a view of a platform incorporating the inventive fluid assembly, corresponding to that in Fig. 6, and for a wearer's left foot;

Fig. 9 is a partial cross-sectional, side elevation view of the fluid assembly and platform in Fig. 8;

Fig. 10 is a schematic representation of a footwear piece with a fluid assembly as in Figs. 6-9 incorporated;

Fig. 11 is a side elevation view of a modified form of fluid assembly according to the present invention, and consisting of two sheet layers which are strategically joined to each other;

Fig. 12 is a schematic representation of another form of fluid assembly, according to the present invention, including an adjustable valve structure;

Fig. 13 is a schematic representation of kit, according to the present invention, including a footwear piece and two fluid assemblies, having different operating capabilities, that can be selectively incorporated into a footwear piece;

Fig. 14 is a flow diagram showing a process for manufacturing footwear pieces utilizing the inventive fluid assembly;

Fig. 15 is an enlarged, fragmentary, cross-sectional view of the fluid assembly taken along line 15-15 of Fig. 7 and showing a valve for controlling flow of fluid between separate chambers in the fluid assembly and including an apertured gate;

Fig. 16 is a cross-sectional view of the fluid assembly and gate taken along line 16-16 of Fig. 15 and with the gate in a closed/restricted position; and

Fig. 17 is a view as in Fig. 16 with the gate in an open position.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring initially to Figs. 1 and 2, the human mechanism for walking or running is depicted. The lower portion of a human leg 10, including the foot 12, are shown. The foot 12 has a rear heel 14 and a sole 16, midway between the heel 14 and toes 18. As one runs or walks, the heel 14 is impacted with an underlying surface 20 with the foot 12 in the Fig. 1 position. In this position, the toes 18 point angularly upwardly, with the ball 22 of the foot 12 elevated above the surface 20. At this stage, the impact force from the person's weight 10 is

imparted to the heel 14 and the ankle 24, and ultimately to the knee, leg, hip, spine, and associated body parts (not shown).

The movement progresses to the Fig. 2 stage, in which the individual pivots on the heel 14 so that the ball 22 of the foot 12 contacts the underlying surface 20 and the heel 14 elevates. At this stage, the individual's weight becomes borne by the ball 22 of the foot 12 and the toes 18 which are simultaneously pressed against the surface 20. Propulsion is effected through the toes 18 and ball 22 of the foot 12, which are pressed against the surface 20 and through which the individual pushes off the surface 20 to generate an upward and forward movement. Once the foot 12 pushes off of the underlying surface 20 from the Fig. 2 position, the foot 12 strides through the air in an arc until the Fig. 1 position is again realized. These actions are continuously repeated during both the walking and running processes.

In Figs. 3-5, the above-described walking/running sequence is shown with respect to an exemplary footwear piece 26. The footwear piece 26 has a platform 28 which extends from the front 30 to the rear 32 of the footwear piece 26. The platform 28 consists of a heel 34 and a sole/outsole 36 forwardly of the heel 34. The wearer's foot is received in a receptacle 38 defined by a boot/upper 40.

As the wearer walks/runs, the heel region at 42 initially contacts the underlying surface 20, with the sole region at 44 angled upwardly from rear to front as shown in Fig. 3.

The footwear piece 26 is then pivoted at the heel region 42 to place the sole region 44 in contact with the underlying surface 20, as shown in Fig. 4. The heel region 42 is then elevated above the underlying surface 20 and causes the boot/upper 40 to hinge at a midportion 46 and the sole/outsole 36 to bend correspondingly in the region therebeneath.

As the wearer pushes off from the Fig. 4 position, the entire footwear piece 26 becomes elevated to the Fig. 5 position, wherein the footwear piece

26 is relaxed to the normal configuration shown therein. The foot will stride in the Fig. 5 position and then return to the impact position of Fig. 3.

The impact to push-off time interval is short relative to the stride interval. The primary impact forces are encountered with the foot 12 and footwear piece 26 in the Figs. 1 and 3 positions, respectively. It is at that moment that potentially damaging forces are encountered which are absorbed through the footwear piece 26 and the wearer's body.

According to the invention, a fluid assembly 50 is provided for incorporation into each footwear piece 26. In Figs. 6 and 7, the fluid assembly 50 is shown for use on a "right" foot. A corresponding fluid assembly 50' is shown in Figs. 7 and 8 for the left foot. Elements in Figs. 7 and 8, corresponding to those in Figs. 6 and 7, are identified with the same number and using a "' " designation. The fluid assemblies 50, 50' are mirror images of each other, and thus the description herein will be limited to the exemplary fluid assembly 50.

In Fig. 7, the fluid assembly 50 is shown on the platform 28, previously described. The fluid assembly 50 has a body 52 that conforms generally to the peripheral outline 54 of the platform 28. Alternatively, the fluid assembly 50 may have a smaller size and a different shape which occupies less of the area of the platform 28, as viewed from above. The body 52 has an optional cushion portion 56 to conform generally to the plantar arch 57 (Fig. 2) on the user's foot 12.

The fluid assembly 50 has a first chamber 58 and a second chamber 60 in fluid communication with each other through a passageway 62. Each of the chambers 58, 60 is designed to contain a discrete volume of a fluid 64 which is allowed to flow between the chambers 58, 60 via the passageway 62. In the embodiment shown, the first chamber 58 is disposed over the heel region 42 of the platform 28 and has a greater thickness than that of the second chamber 60 disposed over the sole region 44 of the platform 28. In this embodiment, the

chamber 58 has a layer 66 with a generally circular footprint on the platform 28 with the chamber 60 having a correspondingly configured layer 68 with a larger diameter. The particular shape of the layers 66, 68 is not material to the present invention.

5 As the wearer's heel 14 is pressed against the layer 66, the layer 66 deforms downwardly to effectively reduce the volume of the space 70 in the chamber 58. Similarly, downward pressure applied to the layer 68 causes the volume of the space 72 in the chamber 60 to be reduced. In each case, this produces an hydraulic action which forces fluid from the chambers 58, 60.

10 In one form, the layers 66, 68 are each made from flexible sheets which deform downwardly under pressure from the foot 12. It should be understood that virtually any pressure responsive structure which reduces the volume of the spaces 70, 72 could be used to practice the present invention. As just one example, the layers 66, 68 could incorporate a relatively hard, flat, material
15 which acts as a plunger in response to pressure application.

 With the inventive structure, as the heel 14 of the wearer's foot 12 is pressed against the chamber 58 in the heel region 42, fluid 64 within the space 70 is squeezed into the passageway 62. A valve at 74 provides a restriction to fluid flow from the chamber 58 in the direction of the arrow 76 in a prescribed
20 first path through the passageway 62 to the chamber 60. The valve 74 is preferably constructed so that the fluid 64 continues to be squeezed/bled from the space 70 during the entire time period that the user's heel 14 is applying a downward force in the Fig. 1 position. This produces an hydraulic action whereby the impact force from a wearer's foot is progressively absorbed during
25 the impact interval. The valve 74 may take any of myriad different designs that might be devised by those skilled in this art.

 Accordingly, the impact of the heel 14 causes a discrete quantity of the fluid 64 from the chamber 58 to be moved through the passageway 62 into the chamber 60. As the wearer continues to walk/run, the Fig. 2/ Fig. 4 state is

achieved at which stage the ball 22 of the user's foot 12 impacts the chamber 60 in the sole region 44. Since the foot 12 is pivoted to bring the ball 22 of the foot 12 into contact with the underlying surface 20 through the platform 28, the magnitude of the impact is not as great as the initial impact of the heel 14 on the underlying surface 20 through the platform 28. The valve 74 is designed so as to offer little impedance to the flow of fluid 64 in the first path, oppositely to the direction indicated by the arrow 76, from the second chamber 60 to the first chamber 58, to re-establish the fluid volume in the first chamber 58 for the next heel impact. Thus, during the time interval in which the foot 12 is in the position shown in Figs. 2 and 4, the fluid 64 flows with little restriction from the second chamber 60 back into the first chamber 58 past the valve 74. Nonetheless, the fluid in the second chamber 60, as it is squeezed out of the space 72, produces an hydraulic action that absorbs forces imparted to the foot in the Fig. 2/Fig. 4 state.

The fluid assembly 50 shown is an operatively "closed system" between the first and second chambers 58, 60. By flowing back and forth between the chambers 58, 60, the fluid 64 is not volumetrically confined to the point that its absorbing capability is reduced as the fluid 64 is squeezed within the chambers 58, 60 during impact.

While the system is described as closed, it is possible to introduce additional fluid from a supply 80 or exhaust fluid to the supply 80, at a separate location, to change the operating characteristics of the fluid assembly 50. Once additional fluid 64 is added or fluid 64 is removed, the fluid assembly 50 may re-assume its closed system configuration.

The fluid assembly 50 shown is intended to be only exemplary in nature. Myriad variations from this basic construction are contemplated. Some of the many variations contemplated are described below. While it is desirable that the fluid 64 from the first chamber 58 be discharged to the second chamber 60 so that the latter can perform an absorbing function, this is not required. Fluid

64 from the chamber 58 could be communicated to a separate chamber 82, either internally, or externally, of the boot/upper 40. The fluid in the chamber 82 can, by any means, be recirculated to the chamber 60. For example, this can be accomplished by simply a delayed hydraulic action or through an active pump mechanism. Alternatively, the fluid 64 could be periodically or continuously replenished from the separate supply 80.

Another variation is shown in Fig. 6 wherein a passageway 84, separate from the passageway 62, is utilized to circulate fluid 64 from the second chamber 60 back into the first chamber 58. Accordingly, the fluid 64 moves in different, prescribed paths, depending upon which direction it is flowing between the chambers 58, 60.

Further, the number of chambers utilized, as well as their specific configuration, is a design choice. The chamber 58 can be made relatively thick to provide the desired cushioning effect for heavy users and/or under high impact conditions. Due to the hydraulic action resulting at the chamber 58 during walking/running, a thick cushion can be formed without producing any instability that might otherwise result in the heel region 42 as a consequence of using a thick, fixed volume cushion. There may be interaction of some or all of the multiple chambers to achieve the ends, previously described.

The nature of the footwear piece 26 is likewise not critical to the present invention. As shown generically in Fig. 10, a footwear piece 26' may include any type of platform 28' and any type of boot/upper 40', with which the fluid assembly 50 is associated. For example, the platform 28' may be in a sandle form with a continuous, substantially flat surface between the sole and heel. Alternatively, heels of different height and cross section could be utilized. The platform 28' can incorporate athletic cleats and may have virtually any type of contoured shape. The boot/upper 40' could be in the nature of straps, a continuous layer, or a combination of these components.

The fluid assembly 50, as a unit, might be removably installed with respect to the boot/upper 40' and platform 28'. Alternatively, the fluid assembly 50 could be fixedly attached to one or both of the boot/upper 40' and platform 28', either by being integral with one or the other, or fixedly mounted thereto, as by an adhesive.

The fluid assembly 50 can be incorporated into the platform 28 any place between the top and bottom thereof, i.e. as shown at the top, or at an intermediate height.

As shown in Fig. 11, the entire fluid assembly 50' may be made with substantially similarly configured layers 86, 88 that are strategically joined to produce the desired chambers and passageway(s) communicating therebetween. For example, the layers 86, 88 may be made from a meltable plastic, with the layers 86, 88 strategically heated to be bonded to each other in all but the regions at which chambers 90, 92, and passageways 94, therebetween, are formed.

The invention also contemplates custom fitting either at the time of manufacture, or by retrofitting fluid assemblies into footwear pieces, as shown in Figs. 13 and 14. As shown in Fig. 13, first and second fluid assemblies 50'', 50''' can be manufactured with different operating capabilities, which depend upon a person's foot size, weight, or another characteristic. Depending upon the predetermined needs of the wearer, either the first or second fluid assembly 50'', 50''' is installed in the footwear piece 26.

Accordingly, as shown in Fig. 14, the footwear design process can initially be carried out by determining specific user characteristics, as shown at block 120. This analysis may take into account a user's weight, foot size, or other specific characteristic(s) of the user. Once the user characteristics are identified, a fluid assembly may be either custom designed, as shown at block 122, or selected from a range of fluid assemblies which are mass produced to encompass a range of different operating characteristics. That which is most

appropriate to the particular user is selected and installed, as shown at block 124. Again, this process can be performed either at the time of manufacture or in a retrofitting process.

5 The nature of the fluid 64 can likewise vary considerably. The fluid may be one, or a combination of, a gas, or a liquid, such as water, or a substance in gel form.

10 The valve 74 may take a number of different forms. As shown generically in Fig. 12, the valve 74' on the fluid assemblies 50, 50', 50'', 50''' may have an adjusting capability to allow variation of the flow rate between the first and second chambers 58, 60 for a given pressure.

15 One exemplary form of the valve 74 is shown in detail in Figs. 15-17. The valve 74 consists of an apertured gate 130 that is movable between open/unrestricted and closed/restricted positions, shown in Figs. 17 and 16, respectively. The gate 130 is pivotably connected to the layer 86', corresponding to the layer 86. The gate 130 may be integrally formed with the layer 86' so as to define a live hinge at 132, or defined by a separate, joined element. The gate 130 has a shape that is matched to the cross section of the passageway 62. In the closed/restricted gate position, a surface 134 on the gate 130 abuts to a surface 136 on a blocking wall 138 on the layer 88'.

20 In the closed/restricted position, fluid is allowed to flow from the chamber 60 to the chamber 58 only through a series of apertures 140 through the gate 130. The number and shape of the apertures 140 is a design consideration. It is desirable that the combined flow area of the apertures 140 is substantially less than the area of the gate surface 142, corresponding to the cross-sectional configuration of the passageway 62. Accordingly, the fluid 64, in response to
25 increased pressure in the chamber 58 caused by the user's heel 14, bleeds through the apertures 140 in the passageway 62 from the chamber 58 into the chamber 60 continuously under the applied force. The produces the absorbing hydraulic action, previously described.

In response to the increase in pressure in the chamber 60, due to the application of a force through the toes 18 and ball 22 of the user's foot, fluid flows from the chamber 60 towards the chamber 58, through the passageway 62, and in so doing, repositions the gate 130 to the open/unrestricted position of Fig. 17. In the gate "open" position, fluid 64 is allowed to flow substantially unimpeded by the gate 130 at a greater rate than it is allowed to flow at from the chamber 58 to the chamber 60.

As noted above, the valve 74 described is but exemplary of the many different valve configurations contemplated. This valve construction could be varied to change the operating characteristics of the fluid assembly 50. For example, the cross-sectional shape and dimension of the passageway 62 can be changed to provide a range of different sizes and shapes which account for different operating characteristics for the fluid assembly 50. Changes in operating characteristics can be effected by providing fluid assemblies 50 with different numbers, sizes, and configurations of apertures 140.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.